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COMPARISON OF THREE DISPLAY DEVICES FOR UNATTENDED GROUND SENSORS.

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BATTLEFIELD INFORMATION SYSTEMS TECHNICAL AREA

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is given
Requirement: To determine the relative values of the operational RO 376 event recorder, a situation map display, and the use of time compression with the situation map display for displaying activations of seismic unattended ground sensors under typical operational conditions affecting the interpretation of these displays.

Procedure: Three tape recordings, each 2 hours long, of the activations of unattended ground sensors were compiled from the data bank of recordings of — next page

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unattended ground sensor activations taken during Project 1030 and BASS III tests at MASSTER. Typical patterns at two levels of target activity were selected for personnel and vehicular targets. Aircraft, artillery, and background noise were added to simulate operational noise. These recordings were played back to activate the three displays.

Results: Use of the operational RO 376 resulted in higher accuracy and completeness of reports than did use of the other displays. No differences were found between the situation map display and the situation map display with time compression. Target activity level, order effects, and composition of taped activations affected operator performance. Another study, similar to the present one, but with sensors deployed using the area intrusion concept of sensor employment (i.e., the "grid" or "gated array" deployment) would broaden the basis for evaluation.

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COMPARISON OF THREE DISPLAY DEVICES FOR UNATTENDED GROUND SENSORS

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BATTLEFIELD INFORMATION SYSTEMS TECHNICAL AREA

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Surveillance Systems

ARI Research Reports and Technical Papers are intended for sponsors of R&D tasks and other research and military agencies. Any findings ready for implementation at the time of publication are presented in the latter part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The Battlefield Information Systems Technical Area is concerned with the demands of the future battlefield for increased man-machine complexity to acquire, transmit, process, disseminate, and use information. The research focuses on the interface problems and interactions within command and control centers in areas such as topographic products and procedures, tactical symbology, information management, user-oriented systems, staff operations and procedures, and integration and use of sensor systems.

An area of special interest is that of problems of human factors in the presentation and interpretation of surveillance and target acquisition information. One relatively new source of intelligence information is remote monitoring of the battlefield using seismic, acoustic, and magnetic unattended ground sensors. When these remote sensors are activated by enemy personnel or vehicle movement, a monitor display located behind our lines indicates the activity. From this display the operator can derive not only the presence of the enemy but the direction and speed of convoys and personnel, the number of vehicles in a convoy, and the composition of the convoy, for example, whether it consists of armored or wheeled vehicles.

The present publication reports the initial investigation of operator display needs for unattended ground sensor systems. The operational type of display, the RO 376, event versus time recorder, was compared to two types of situational map displays and found to be superior. (ARI Technical Paper 281 compared the relative effectiveness of four different unattended ground sensors in terms of their effects on monitor performance.)

This research was done in cooperation with the Combat Surveillance and Target Acquisition Laboratory of the U.S. Army Electronics Command at Fort Monmouth, N.J. It is responsive to requirements of Army Project 2Q662704A721 and special requirements of the Office of the Assistant Chief of Staff for Intelligence and the Remotely Monitored Battlefield Sensor System Project. The cooperation of the U.S. Naval Inshore Warfare Command, Atlantic, and of LCDR E. Hockey in particular, is gratefully acknowledged. Without this excellent support, the quality and timeliness of this experiment would have been seriously impaired.

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COMPARISON OF THREE DISPLAY DEVICES FOR UNATTENDED GROUND SENSORS

BRIEF

Requirement:

The experiment was designed to determine the relative values under typical operating conditions of three methods of displaying activations of seismic unattended ground sensors: use of the operational RO 376 event recorder, use of a situation map display, and use of time compression with the situation map display.

Procedure:

Three tape recordings lasting 2 hours each of the activations of unattended ground sensors were compiled from the data bank of recordings of unattended ground sensor activations taken during field tests under simulated operational conditions. Typical patterns at two levels of target activity were selected to include both personnel and vehicle targets. To provide realistic simulation, recorded activations of aircraft, artillery, and background noise likely to affect the interpretation of displays were included.

Twelve Naval personnel trained and experienced in the use of the RO 376 were given 4 hours training in the use of the situation map display and the display used with time compression. Each subject then interpreted each of the three displays using a different set of recorded activations each time, in counterbalanced order, and filled out a standardized report form. The reports were scored for number of correct detections and number of false alarms in comparison with the known target activity observed in the Modern Army Selected Systems Test, Evaluation, and Review (MASSTER) tests at Fort Hood, Tex.

Findings:

Use of the operational RO 376 resulted in higher accuracy and greater completeness of reports than did use of the other displays. No differences were found between the situation map display and the situation map display used with time compression.

Target activity level, order effects, and composition of the taped activations affected operator performance.

Utilization of Findings:

The experiment reported here was an early effort in a series to improve the interpretation of UGS activations. Because of its superiority, the RO 376 event recorder should be used instead of the situation map display in interpreting activations of sensors deployed in strings.

An additional study that would deploy sensors using the area intrusion concept of sensor deployment ("grid" or "gated array") could be an additional, useful basis for evaluation.

In view of the effect on performance of target activity level, order effects, and composition of taped activations, these conditions must be controlled in further evaluations of ground sensors in which operators interpret and report intelligence information.

COMPARISON OF THREE DISPLAY DEVICES FOR UNATTENDED GROUND SENSORS

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COMPARISON OF THREE DISPLAY DEVICES FOR UNATTENDED GROUND SENSORS

Two basic types of unattended ground sensor (UGS) displays are being considered for major use by the Army: the operational event versus time (XT) recorder and the situation map display. The evaluation of these devices under operational conditions was an early step in a program seeking to improve operator performance in interpreting and reporting displays of UGS activations.

THE DISPLAY DEVICES

The Operational Event Recorder

The two operational forms of the XT recorder are the 30-pen RO 376 event recorder and the BASS III 60-pen recorder. These devices portray time vertically and denote the activations of sensors in the field by short horizontal lines in specified columns; each column is associated with the return from a single sensor. The resulting permanent record, plus information about where the strings of three or more sensors are deployed, how far apart they are, and what type of sensor is being used, enables the operator to make one or more of the following estimations:

1. when a possible enemy activates a sensor,

2. how many and what kind of enemy objects are present (personnel, vehicles, or aircraft),

3. where they are,

4. what direction they are going, and

5. what speed.

Because the record is permanent, the operator's report can be checked. Likewise, the battalion intelligence officer (S2) or others in similar operations positions can review fairly quickly the type of action that has occurred in the past few hours.

The Situation Map Display

The situation map display consists of a map placed over small lights that correspond to the location of a sensor in the field. The light blinks rapidly several times for each activation of its associated sensor and then goes off until the next sensor activation. (Most sensors have a short rest period of 4 to 10 seconds during which they cannot be reactivated.) At present, prototype 30 and 120 sensor displays

have been constructed. There is no permanent record of the activations with these devices except by the proposed addition of a tape recorder or similar device to record incoming signals. Using a tape recorder would make it possible to resend the signals to the map display and reactivate the lights.

An advantage of the situation map display is that it helps the operator quickly identify the location and direction of movement of the source of activations by direct simultaneous observation of the map and activations. A potential advantage of this system is the capability to review activations in compressed time by playing the proposed tape recording at a higher speed. Target activations that would be missed because of noise or slow velocity of the target past the sensors might be discovered more easily in time compression.

Similarly, if only the last sensor or the last two sensors gives strong returns, playback showing the first couple of sensors in the string with knowledge that the last returns are strong may be helpful (although suggestion effects also may cause false alarms). In addition, someone like the S2 could quickly see the entire situation developing in the context of the map with all its information, including location of defense positions, supplies, and reserves. He could very quickly review what had occurred in the last several hours and determine the pattern and perhaps the enemy's intention.

Displays of both types have been proposed for future operational use. A comparison of the two types in a variety of situations and a determination of the usefulness of a time-compression aid with the situation map display are requirements of one in a series of research projects concerning factors affecting the performance of operators monitoring remote sensing devices. Although the value of the RO 376 event recorder has been established experimentally, the value of the situation map display and of the situation map display with time compression has not.

OBJECTIVES

1. To determine the effectiveness of time compression as a display technique by comparing, under typical operating conditions, the relative utility of the RO 376 plotter, the situation map display, and the situation map display using the time-compression technique.

2. To obtain estimates of operator performance indexes using the RO 376 and the situation map display under a variety of operational conditions.

METHOD

Population and Sample

Army enlisted operators who have been school trained at Fort Huachuca and who have had some field experience constitute the population of concern. Because of the difficulty in obtaining a sufficiently large sample of experienced Army personnel at one location, 12 Navy personnel were used; of these, 10 were school trained and had field experience in several maneuvers. Two had had on-the-job training and no experience. All subjects were given 4 hours of training on the use of the situation map display and compressed time. In addition, the 2 inexperienced subjects were given a review on the use of the RO 376 recorder.

Independent Variables

1. Displays. The three displays were the RO 376 event recorder, the situation map display, and the situation map display used with time compression.

2. Experience. Each subject was ranked by the commanding officer on amount of experience in reading out UGS displays. The subjects were then separated into a high group and a low group. The rankings were checked against self-report data. The high group averaged 25 weeks of total experience, and the low group averaged only 8 weeks. The high group also averaged 4.8 weeks of participation in UGS exercises; the low group averaged only 2.6 weeks.

3. Scenario. Three 2-hour scenarios were developed; each scenario was divided into two 30-minute, high-activity sections and two 30-minute, low-activity sections. Each section contained both walking personnel and vehicular targets.

4. Periods. Each operator worked for 12 30-minute periods. This variable has no intrinsic meaning. In the analysis, however, it was divided into Time, Day, and Activity variables.

5. Time. The first hour of a scenario versus the second hour--a measure of short-term time effects.

6. Day. The first scenario given versus the last scenario given (the two on different days)--a measure of longer term time effects.

7. Target Activity Level. The six low-target activity sections of the scenarios (2 to 3 targets per 30 minutes) were compared to the six high-target activity sections (6 to 8 targets per 30 minutes).

8. Order. The three groups of four operators used the displays and scenarios in a different order.

Dependent Variables

1. Detection-Rights. If an operator reported a target at the time a target was activating the designated pens of the display, the response was classified as a Detection-Right. Normally, this variable is perfectly correlated with the detection completeness of a report. Completeness is a ratio (expressed as a percentage) of targets found to total number of targets present. The simpler measure, "Rights," generally was used because it is easier to compute and is readily convertible to completeness. However, completeness figures had to be used with the Activity variable because there are more targets available for detection in the high-activity level than in the low.

2. Identification-Rights. If, in addition to the above, the operator classified the target correctly by type (personnel or vehicle), the response was also classified as an Identification-Right.

3. Detection Wrongs-False Alarms. If an operator reported a target at a time when no target was causing an activation on the designated pens of the display, the response was classified as a Wrong-False Alarm.

4. Accuracy-Detection. This was the ratio (expressed as a percentage) of the number of Detection-Rights to the sum of the number of Detection-Rights and Wrongs (or total number of responses an operator made).

Experimental Design

A three-by-three replicated Greco-Latin square design (Figure 1) was used. Of primary interest were differences in the main effect (the display used) and its interactions with activity level (high or low) and field experience (high or low). An analysis of variance was computed to test for differences because of Displays (3), Order (3), Experience (2), Period (12), Activity Level (2), Time (2), Day (2), Scenarios (3); and the interactions of devices with Activity Level, Day, Time, and Experience, and of Order with Experience. Other simple interactions, such as Scenarios and Day, and higher order interactions were not specifically analyzed but lumped into a residual term. In addition, Dunn's tests[1] were used for testing the significance of differences between means for the Displays variable.

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[1] Dunn, O. J. & F. J. Massey, Jr. Estimation of Multiple Contrasts Using *t*-Distributions. *Journal of the American Statistical Association*, 1965, *60*, 573-583.

	1st Test Session	2nd Test Session	3rd Test Session
Group 1	C-Map display with compressed time	D-Map display	B-RO 376
Group 2	D-RO 376	B-Map display with compressed time	C-Map display
Group 3	B-Map Display	C-RO 376	D-Map display with compressed time

Note: B, C, and D refer to the three 2-hour scenarios.

Figure 1. Greco-Latin square design.

Procedure

Three Uher[1] tape recorders and interface units were used to drive the RO 376 and two 30-light situation map displays. The Uher recorders are capable of being played at speeds ranging from recording speed to eight times recording speed, thereby providing means for "sending" to the display the recorded activations for all conditions of the experiment. Each tape recorder was paired with a single display to permit the flexibility required by the experimental design.

The scenarios were developed from material obtained by taping typical activations produced by personnel, armored vehicles, aircraft, artillery, and noise during Project 1030 and BASS III tests at MASSTER, Fort Hood, Tex. Because these were controlled exercises, target location and time were known and could be related to sensor activations. Typical noise such as that caused by weather, noisy sensors, artillery, and aircraft were not eliminated and were added specifically in particularly uneventful portions of the performance measures. Portions of the above tapes showing "good" target returns were selected and combined into three 2-hour tapes (three scenarios). These tapes were played back to activate the displays to reproduce conditions as they existed in the field.

As stated in defining the Scenario variable, each of the 2-hour tapes was designed to have two 30-minute portions displaying a high-target activity level and two portions displaying a low-target activity level. A target is defined as a group of one to nine personnel or one to six

[1] Commercial designations are given only in the interest of precise description; their mention does not constitute endorsement by the Army.

vehicles passing by and activating the entire string of sensors. The number of targets per scenario and time period is shown in Table 1.

Table 1

Target Distribution

Scenario	Targets per 30-minute period				Number of targets		
	1st	2nd	3rd	4th	Personnel	Vehicle	Total
B	3	8	2	7	9	11	20
C	2	6	2	7	7	10	17
D	2	6	2	7	7	10	17

Three subjects at a time were given a general briefing explaining the purpose of the research and the role of the subjects (Appendix A). The subjects were then given 4 hours of instruction and practice on a situation map display and use of compressed time (Appendix B). If necessary, a review of the use of the RO 376 also was given.

Each subject was assigned to one of the three display-scenario stations for the first 2 hours. After a break (1 hour or overnight), the subject went to another display-scenario station for the second 2 hours. Following another similar break, each subject was assigned to the last display-scenario station. The subjects recorded target information on the report form shown in Appendix C. Their responses were scored against known target information to derive the different scores for the analyses.

RESULTS

Wrongs (False Alarms)

Table 2 shows the analysis of variance results for Wrongs. Of primary interest are the statistically significant differences found on the Displays variable. The average number of false alarms a man a 2-hour period was RO 376, 5.6; map display, 9.8; and map display with TC, 12.6.

Table 2

Analysis of Variance Table for Detection
Wrongs-False Alarms

Variable	df	SS	MSS	F ratio	Significance level
Experience	1	.4444	.4444	.0358	NS
Order effects	2	127.7917	63.8958	5.1460	05
Experience x order	2	82.9306	41.4653	3.3395	NS
Subject within groups	6	74.5000	12.4167		
Displays	2	74.6250	37.3125	15.9394	01
Displays x activities	2	2.9305	1.4652	.6259	NS
Displays x experience	2	13.4306	6.7153	2.8687	NS
Displays x time	2	10.0139	5.0070	2.1389	NS
Displays x day	2	65.3333	32.6667	13.9548	01
Periods	11	85.6667	7.7879	3.3269	01
(Activity)	(1)	(18.7778)	18.7778	8.0216	01
(Time)	(1)	(17.3611)	17.3611	7.4164	01
(Day)	(1)	(10.0104)	10.0104	4.2763	05
Scenarios	2	12.7917	6.3958	2.7322	NS
Residual	43	175.0416	4.0707	1.7389	05
Error	66	154.5000	2.3409		
Total	143	880.0000			

The difference between the RO 376 display and the average of the other two displays (tested by Dunn's test) is statistically significant at the .05 level. Similar comparison of the map display versus the map display with time compressions shows no significant difference. Thus, on the average, twice as many false alarms occurred using the map display as compared to using the RO 376.

The interaction between Displays and Activity Level was not statistically significant. Thus, the difference found between Displays was not restricted to either low- or high-target activity, but can be generalized to both.

Similarly, no significant difference was found for the interactions of Experience and Display. It thus appears that the difference in displays can be generalized over experience. However, contrary to expectations, a significant difference in performance was not found between the high- and low-experience groups. Several factors might explain this finding; for example, that all subjects were "sufficiently" experienced to be relatively homogeneous in performance. However, since experience, in general, should improve performance, the finding is suspect, and generalizations regarding experience should be restricted to the sample used in the present study.

The interaction of Displays and Time (first hour versus second hour of a scenario) was not statistically significant at the .05 level. Thus, the differences found between Displays are not restricted to either the first or second hour of a scenario but can be generalized over the complete 2-hour period and any time effect therein.

To summarize, interactions of Displays with Activity Level, Experience, and Time were not statistically significant. This result indicates that the differences found in Displays can be generalized over Activity Level, Experience, and Time.

The interaction between Displays and Day was statistically significant at the .01 level. Table 3 shows the mean number of Wrongs per 2 hours by Day and Display.

From Table 3, it seems clear that the advantage of the RO 376 display shown earlier occurred over both days. However, the interaction effect apparently indicates that use of the map display without compressed time resulted in a decrease in Wrongs from Day 1 to Day 2, possibly due to a learning effect, whereas use of the other two displays showed a decrement in performance from Day 1 to Day 2. Performance on the map display with time compression in particular exhibited twice as many Wrongs on Day 2. A reason for this interaction such as fatigue, differential learning, or experience factors does not appear reasonable. Further examination of this finding seems indicated. This particular finding does not affect the results or the interpretation of main effect differences for the Display variable because use of the RO 376 resulted in fewer Wrongs on both days.

Table 3

Average Number of Wrongs[a] by Day and Display

	RO 376	Map display	Map display with time compression
Day 1	3.2	13.2	10.2
Day 2	4.5	8.5	21.5

[a]These means cannot be compared to previously given means for displays because they are based on a smaller group.

Statistically significant effects were found for Period. The Period variable is simply the 12 30-minute periods (4 30-minute periods per 2-hour scenario) used in the experiment. Period could be interpreted as some combination of scenario, time, fatigue, and learning effects, and thus is of no value by itself.

The three major components of Period (Activity, Time, and Day) that were thought to have most significance to this research were analyzed further. Table 2 shows a significant difference on all three variables. The high-activity condition resulted in fewer wrong responses (3.9 per hour) than the low-activity condition (5.4 per hour). Thus, it could be theorized that during high activity the operator makes fewer mistakes because he is too busy. However, activity effects could be confounded with a differential difficulty level of each part of a scenario.

Different sets and arrangements of activations were present during each 30 minutes of any one scenario. Thus, the low-activity parts of the scenario could contain more error-producing noise. All scenarios were analyzed with respect to the amount of noise present in each 30 minutes that would cause an operator to report a target. Any noise generated by aircraft, artillery, environment, etc., that caused two sensors in a string to activate within a short period of time was defined as a "possible false alarm." The number of possible false alarms was used as the measure of amount of noise.

Table 4 indicates that a differential amount of noise could cause the differences found in the Activity variable. There were 60 possible false alarms in the low-activity section but only 39 in the high. Thus, there are at least two possible explanations: either the high-activity level prevented mistakes by keeping the operator busy or noise differences between the high- and low-activity sections of the scenarios caused the differences.

Table 4

Number of Possible False Alarms (Noise) for Sections of Scenarios

Scenario	Low activity	High activity	Total
B	15	12	27
C	16	16	32
D	29	11	40
Total	60	39	
	1st hour	2nd hour	
B	13	14	27
C	17	15	32
D	20	20	40
Total	50	49	

The significant time difference (Table 2), that is, the first hour of a scenario versus the second hour, contraindicates a fatigue effect. An average of 5.4 wrong responses were made the first hour as opposed to 4.0 the second hour. However, the second hour of each of the scenarios could have contained more noise and thus have caused this effect.

Table 4 indicates that the first hour and second hour of each scenario were about equal in the amount of noise that could have caused false alarms (50 and 49). Another possible explanation could be learning, except that there was no feedback as to the correctness of each report an operator made. Thus, learning was made very difficult. Also, the analysis of the variable Day (Day 1 versus Day 2) did not indicate a consistent learning effect. If the above difference can be shown in other situations, it could mean that the operator can spend longer periods of time interpreting displays without experiencing a decrement in one aspect of performance (i.e., increasing Wrongs) due to fatigue. This effect will be shown again under the discussion of the Accuracy variable.

The significant difference (Table 2) found between Day 1 (4.5 Wrongs per hour) and Day 2 (5.8 Wrongs per hour) contraindicates learning effects in general (see previous discussion on Display-Day interaction).

Assuming that the Day effect is not long lasting but only an experimental artifact, future UGS experimentation must control for this variable.

The analysis of variance (Table 2) shows no significant differences between scenarios, indicating that the stimulus material used in each scenario was sufficiently similar as to produce equal numbers of false alarms. Because of the observed noise differences between scenarios (Table 4), additional analyses (orthogonal comparisons) were computed between Scenario D and the average of Scenarios B and C and between Scenarios B and C. No significant differences between the means were found.

The significant order effect (Table 2) indicates that the order of presentation of the combination of Scenario and Display affected performance. Future research to improve performance on unattended ground sensors should control this variable.

Detection-Rights

Table 5 presents the analysis of variance results for Detection-Rights. Of most interest is the significant difference (.05 level) found for the Display variable. Use of the RO 376 event recorder resulted in the highest average number of rights for the 2-hour period (15.8) and use of the map display alone, the lowest (14.2). Dunn's test comparing the RO 376 with the two map displays indicated a significant difference at the .01 level. The same test comparing the two map displays showed no significant difference.

The significant (.05) interaction of Displays and Activity is of interest because it shows the difference found in the Displays variable occurred in the high-activity condition only (Table 6). Table 6 also shows the corresponding completeness values in parentheses. Under the low-activity conditions, all displays were about equal (90%). However, the high-activity conditions resulted in lowering completeness to only 77% for the map display and map display with time compression. Thus, in the more difficult situation there was a decrement in performance with these displays.

The display by experience and the display by time interactions yielded no significant effects. Thus, as with the Wrongs analysis, no differences due to experience and time were found with the sample used in the present experiment.

Table 5

Analysis of Variance Table for Detection-Rights

Variable	df	SS	MSS	F ratio	Significance level
Experience	1	1.3611	1.3611	.8099	NS
Order effects	2	.2916	.1458	.0868	NS
Experience x order	2	.5139	.25695	.1529	NS
Subject within groups	6	10.0834	1.6806		
Displays	2	3.8750	1.9375	3.7702	05
Displays x activities	2	4.2639	2.13195	4.1486	05
Displays x experience	2	.2639	.13195	.2568	NS
Displays x time	2	1.3472	.6736	1.3108	NS
Displays x day	2	7.5209	3.7604	7.3174	01
Periods	11	458.0833	41.6489	81.0350	01
(Activity)	(1)	(434.0278)	434.0278	844.5764	01
(Time)	(1)	1.7778	1.7778	3.4594	NS
(Day)	(1)	1.7604	1.7604	3.4256	NS
Scenarios	2	12.1667	6.08335	11.8376	01
Residual	43	40.0625	.9317	1.8130	05
Error	66	33.9166	.5139		
Total	143	573.7500			

Table 6

Mean Number of Right Detections per Hour for the Displays and Activity Levels

Level	RO 376	Map display	Map display with time compression
High activity	11.9 (87)[a]	10.3 (76)	10.5 (77)
Low activity	3.9 (90)	3.9 (90)	4.0 (92)

[a]Completeness (100 x Rights divided by total number of targets).

A significant difference was found for the interaction of Displays and Day. Table 7 gives the mean number of Detection-Rights for each display for each day. The superiority of the RO 376 is clearly associated with whatever the Day effect represents. Day 1 performance with the RO 376 was about equal to that for the other displays. On Day 2, the RO 376 was clearly superior. The reason for this effect is hard to determine, but one hypothesis is related to pretest training. Because all subjects had some practical experience in using the RO 376 display on field exercises, essentially no pretest training was given on the RO 376; all available time was devoted to the map displays and time compression. Conceivably, a warmup, acclimatization, or practice was needed to bring the subjects up to their normal efficiency on the RO 376.

Table 7

Mean Number of Right Detections per 2-Hour Period for Displays and Day

Day	RO 376	Map display	Map display with time compression
Day 1	13.8	15.5	14.5
Day 2	18.0	15.0	14.0

The significant difference found for Period (Table 5) could be attributable to various time or scenario-related variables. Three variables (Activity, Time, and Day) were selected as relevant to this study. A major cause of the difference found was the Activity variable. The significant difference found for the Activity variable was expected, because there are many more targets in the high-activity section of the scenario than in the low-activity section. No significant difference was found for either the Time or Day variable.

The difference found for the scenarios was to be expected, and the design of the experiment took this prospect into account in order not to confound other variables. The differences in Rights are attributable to differences in number of targets in each scenario and to differences in target difficulty.

Order effects were not significant. Neither the order of stimulus material nor that of the displays used affected performance.

Identification-Rights

Table 8 presents the analysis of variance results for Identification-Rights. No significant difference was found for the Displays variable. Use of the RO 376 event recorder resulted in 14.2 correct identifications for the 2-hour period; use of the map display with and without time compression resulted in 13.2 and 13.3 correct identifications, respectively. Dunn's test indicated no significant difference between the RO 376 and the average of the two map displays and between the two map displays.

These results are quite different from those for Detection-Rights. Apparently, the RO 376 made it possible for the operator to detect more targets than with the other displays. There was, however, no significant advantage among displays in identifying targets. Except for these differences, the analyses of variance for Detection- and Identification-Rights (Tables 5 and 8) gave similar results. The preceding discussion for Detection-Rights applies also to the Identification-Rights.

Detection Accuracy

Table 9 shows the results of the analysis for detection accuracy (100 x Rights, divided by the total number of targets reported). The average accuracy of the operator's reports was 80.1% using the RO 376, 64.8% using the map display, and 58.8% using the map display with time compression. Dunn's test comparing the RO 376 to the average of the other two showed a significant difference at the .01 level. The same test comparing the two map displays was not significant.

Table 8

Analysis of Variance Table for Identifications

Variable	df	SS	MSS	F ratio	Significance level
Experience	1	6.2500	6.2500	.8287	NS
Order effects	2	1.3472	.6736	.0893	NS
Experience x order	2	2.0417	1.0208	.1354	NS
Subject within groups	6	45.2500	7.5417		
Displays	2	1.7222	.8611	.9057	NS
Displays x activities	2	2.3889	1.1944	1.2562	NS
Displays x experience	2	.1667	.0834	.0877	NS
Displays x time	2	1.0555	.5278	.5551	NS
Displays x day	2	9.5209	4.7604	5.0067	01
Periods	11	387.555	35.2323	37.0554	01
(Activity)	(1)	(354.6944)	354.6944	373.0484	01
(Time)	(1)	(2.7778)	2.7778	2.9215	NS
(Day)	(1)	(1.0416)	1.0416	1.0955	NS
Scenarios	2	11.5139	5.7570	6.0549	01
Residual	43	48.6597	1.1316	1.1902	NS
Error	66	62.7500	.9508		
Total	143	580.2222			

Table 9

Analysis of Variance Table for Accuracy

Variable	df	SS	MSS	F ratio	Significance level
Experience	1	2.0065	2.0065	.0013	NS
Order effects	2	9,740.7915	4,870.3958	3.0763	NS
Experience x order	2	7,963.7645	3,981.88250	2.5151	NS
Subject within groups	6	9,499.2916	1,583.2153		
Displays	2	11,510.0415	5,755.0208	21.1803	01
Displays x activities	2	341.4305	170.71525	.6283	NS
Displays x experience	2	3,761.7645	1,880.88225	6.9223	01
Displays x time	2	872.1808	436.0904	1.6050	NS
Displays x day	2	3,172.1458	1,586.0729	5.8373	01
Periods	11	16,424.3541	1,493.1231	5.4952	01
(Activity)	(1)	(11,574.1735)	11,574.1735	42.5967	01
(Time)	(1)	(1,813.3402)	1,813.3402	6.6737	05
(Day)	(1)	(26.0417)	26.0417	.0958	NS
Scenarios	2	11,921.9995	5,960.9998	21.9384	01
Residual	43	18,690.4583	434.6618	1.5997	05
Error	66	17,933.2084	271.7153		
Total	143	111,833.4375			

The interaction between Displays and Activity was not significant, indicating that the differences between displays can be generalized across activity levels. However, the interaction of Displays with Experience was significant at the .01 level. Table 10 presents the mean accuracy by display and by experience level. The high-experience group obtained a higher mean accuracy than the less-experienced group when using the map display and map display with time compression. The less-experienced group, however, had a higher mean accuracy when using the RO 376. This inconsistency again casts doubt on the nature of the Experience variable because, in general, more experience should result in better performance, especially on the RO 376, the device on which the "experienced" operators would have had experience. When experience alone was considered, however, the analysis of variance showed no difference between the two groups, according to the findings for Wrongs, Detection-Rights, and Identification-Rights.

Table 10

Mean Accuracy for Displays and Experience Level

Level	RO 376	Map display	Map display with time compression
High experience	72	68	63
Less experience	87	62	55

The significant interaction (Table 9) between Display and Day is predictable from the results of Wrongs and Rights analyses. Table 11 exhibits these mean accuracy results with slightly better performance on the second day for the RO 376 and map display, and poorer performance on Day 2 for the map display with time compression. The difference on the RO 376 from Day 1 to Day 2 is probably due to scenario differences, but the other differences cannot be explained in this way. Further experimentation on this differential effect is needed.

The significant effect found for the Periods variable is attributable to the Activity and Time variables that were significant at the .01 and .05 levels, respectively. The mean accuracy found for the high-activity condition was 77% as compared to the mean for the low-activity condition of 59%. The lower accuracy found for the low-activity conditions might appear to contradict logic because the operator has more time during the low-activity conditions. However, this result may be largely attributable to a greater number of targets presented in the

high-activity section of the scenarios and the greater number of possible false alarms due to noise in the low-activity sections (see Table 4).

Table 11

Mean Accuracy by Displays and Day

Day	RO 376	Map display	Map display with time compression
Day 1	83	61	58
Day 2	88	69	41

The significant time effect shows that overall performance improved from 64% during the first hour of a scenario to 71% for the last hour. This change is largely due to a decrease in wrong response because there were no significant differences for the Rights variable.

The difference found for the scenarios was expected and is a reflection of the differences found for the Detection-Rights variable due to differences in number and difficulty of the targets in each scenario. The experiment was designed to control these differences in order not to confound other variables and to increase the sensitivity of the analysis.

CONCLUSIONS AND DISCUSSION

The data concerning the Display variable are consistent. Use of the RO 376 resulted in a more accurate and complete report. No advantage could be found in using either the map display or the map display with time compression. Moreover, no significant differences could be found between the two types of map displays. These results hold both for false alarms and for accuracy of report, regardless of activity level. With regard to completeness, however, use of any of the three displays resulted in equally good performance during low-target activity. Under high-target activity, use of the RO 376 resulted in more correct target detection than did the other displays.

The superiority of the RO 376 was found for both levels of experience represented in this experiment. However, experience as measured here did not relate to performance, thereby casting doubt on the meaning of the term. Different results might occur between the groups used in this experiment and a group just graduating from training.

The other variables--Time Periods, Scenarios, Order--were included as control variables. Significant effects generally were found for these variables. Thus, in future experimentation, these variables must be controlled.

The objective measures of performance used in the experiment--accuracy and completeness--assist the commander in assessing the usefulness of intelligence generated by experienced personnel using the operational RO 376 unattended ground sensor display for situations similar to those used in this research. The performance accuracy of 80% and report completeness of 88% attained with use of the RO 376 indicate that this system is providing valid information. There is, however, room for improvement. In subsequent experiments of this series, other variations in conditions under which the RO 376 is used should be included. Indexes of performance may vary, depending on factors in the operational situations such as operator experience, sensor type and mix, sensor deployment, target size, number of targets, target speed, soil type, noise factors, etc. Combining these results with those of other controlled studies will result in a more accurate estimate of the capabilities of UGS systems.

A possible factor mitigating the above conclusions was the Proficiency factor. The operators were experienced in the use of the RO 376, but had not actually used the map display prior to the training given for the experiment. Although they were given 4 hours training and practice, it is not known if this was sufficient to increase their proficiency in using these devices to the level of the RO 376. Analyses comparing the Day 1 to Day 2 performance showed no differences, indicating that no learning took place in that brief period. Actually, more wrongs were found for Day 2 than for Day 1, which contraindicates learning. It is still possible, however, that experience could be confounding the Display variable.

A limiting factor to the feasibility of generalizing results is the sampling used in designing the scenarios. The scenarios did contain operationally valid activations by both personnel and vehicles plus some of the usual background noise associated with a battlefield situation. The sensors were operational sensors, employed in strings similar to those used in Viet Nam, and the operators were required to report normal target information. The sensors were not deployed as they would be for the area intrusion concept, however, in which sensors are deployed in checkerboard fashion. This type of deployment may present more problems to RO 376 operators than does deployment in strings. The typical stair-step pattern used by operators to detect the presence of targets will no longer be as obvious. Under the area intrusion concept, the path of a target may be more obvious on a map display than on the RO 376, especially having time compression capability to allow the operator a quick review. Also, the patterns of several targets through an area may be much easier to determine using a map display with time compression.

Implications of the Findings

1. When sensors in strings are used, the operational RO 376 event recorder or similar device should be used rather than the situation map display or situation map display with time compression.

2. Results showed the necessity of controlling certain variables--level of target activity, order of presentation, and scenario composition--in subsequent tests of displays for more refined evaluation.

3. An additional study using sensors deployed for area intrusion detection should be accomplished before discarding map displays or time compression techniques as useful devices for the field.

APPENDIX A

BRIEFING FOR EXPERIMENT TO EVALUATE UGS DISPLAYS

I am Mr. Hilligoss, a research psychologist with the U.S. Army Research Institute in Arlington, Virginia. Mr. Lavicka, Mr. Parker, and Mr. Thorpe are electronics experts from the U.S. Army Electronics Command, Fort Monmouth, N.J.

Our purpose in coming to this command for this week and a half is to evaluate, with your assistance, three types of unattended ground sensor displays. The Navy has agreed to cooperate for several reasons but mainly because they are just as interested in UGS displays as i the Army. In order to objectively evaluate these displays, we need you, as trained specialists, to use each of them so that we can determine which display results in the best performance, that is, in fewer false alarms and a greater number of correct reports of enemy activity. Thus, you are helping to determine what equipment you may use in the future.

We have taped actual sensor activations in the field at Fort Hood, Tex., under simulated battlefield conditions including typical noise, such as artillery, helicopters, and wind. These tapes will be played back to activate the three display devices. You will interpret the displays and make a report much as you would operationally, but using our report forms. Since we know where and when target activations actually occurred, we can score your reports for accuracy and thereby determine which is the best display.

You will work on this experiment for about 2 days. During that time, you will be given training on the new display equipment and a practical exercise to familiarize you with the test situation. Then you will work with each type of display for 2 hours, with appropriate breaks, lunch, etc. If you cannot be here during the scheduled time, tell us now so we can reschedule you. You must be here for all scheduled times or we cannot use your results. Here is your schedule for the experiment. (Note: Make up is possible but do not advertise.)

Now about the displays. The first, the RO 376 event recorder, you have trained on and have worked with in the field. This will be the standard display because it is the present operational device. Your reports using this device will be compared to your results with the other devices. Training on the RO 376 will be minimal since this device should be familiar to you.

The second display, the situation map display, is simply a map with lights indicating the location of the sensors. Each sensor activation causes the corresponding light to blink for 5 seconds. Thus you can see the progression of the enemy on the map by which light is blinking. Finding location and direction is easy, of course, but getting

speed may be a little more difficult. Naturally, we will give you practice on this device and you will not be required to maintain or set it up--just interpret!

The third display is identical to the second except that you have a review or playback capability. With the situation map display, you have no permanent record or way of checking on your decisions as you do with the RO 376. However, if, in the field, there were a tape recorder to record the activations, you could play them back if you wished to see the activations a second time. In addition, if you play the recording back at 8 times normal speed, you would, in a sense, compress time, and be able to review more quickly. This also might help you see a pattern more easily. This, then, is your third display--a situation map display that allows you to play back what has happened in the past, at 8 times normal speed. You will notice that during the review period the light will not blink. It comes on for one-half second for each activation. (Pause) As an additional condition of this display, every half hour you will have a required review of what has occurred during the previous half hour but in 8x normal speed. This forced review is another approach we are trying out.

There are, of course, many display ideas and procedures we could, and will, try out. This is only the first of a series of experiments in the area. When you are finished, please give us your ideas.

Your task, then, with this third display will be to interpret the blinking lights, which represent activations in the field, on the map display exactly like the second display. However, if you wish to review what you thought to be a target pattern you would so indicate. We would stop the clock and replay at 8 times normal speed the last few minutes of activations. For the purposes of this experiment, we would pretend no time elapsed during this playback. When the review was over, you would once again view and display in normal time. Then, after 30 minutes (of clock time), you would have a forced review period of about 4 minutes.

Before we explain how to fill out the target report form, are there any questions? (Pause)

Here are the target report form and map sketches of the areas of concern. We are using map sketches to simplify the experiment. Note the first column on your report form. We want to know when you first thought a target might be present. Target indication should be given in terms of the time the target activated the second sensor in the string. Using the second sensor should give you enough time after the first sensor to decide whether a target is present. If this does not give you enough time, then give us the time the target activated the third sensor. But be sure to indicate in the remarks column on your target report form that this is the third sensor.

Indicate in column 2 which sensors are activated. These are the same as pen numbers or the numbers by the lights.

In column 3, put down the time when you finally decide a target is present--this may be the same time as the first column or some time later.

Next, determine the velocity, using a table we will provide. You can accurately measure the time on the RO 376. However, with the map displays you will have to use the clocks to determine the time interval between the activations of different sensors in a string.

In the target type column, you will write either a V for vehicle or P for personnel. This probably will be determined from the velocity column and your experience as an operator.

In the next column, give your estimate of the number of targets present. This will be extremely difficult but do the best you can.

In the next column, we want you to try to give us your confidence that there is a target present. This is an additional piece of intelligence information which has been found very useful in other areas of the intelligence field. We wish to determine how well this judgment can be made and how the use of the different displays affects your estimate.

Use only the numbers 100, 90, 80, 70, 60, 50, 40, 30, 20, and 10. If you put down 90, this means you are quite sure there is a target there, but you expect to be right only 90 times out of 100; if you put 50 down, this means that you estimate that only half the reports so marked will be right. If you put down 10, then only 10% of the time will you be right. Naturally, for all those targets where you put 100 down, you are estimating that you will always be right. Use the next column as is necessary.

If you wish to delete or change anything draw a line through it and write above it either "omit" or the change. Please do not erase.

Are there any questions? (Pause)

What you will be seeing was recorded during maneuvers at Fort Hood, Tex. There will be varying numbers of personnel or vehicles activating the sensors. In addition, there will be the normal noise due to weather, wind, and so forth, and noise from artillery and helicopters. Do not report artillery, helicopters, etc., only personnel or vehicles. You should note on our map simulations, that the intervals in different sensor strings are different. Be careful when computing the velocity information. Always refer back to the map.

Each of the three scenarios will start at 12 midnight (0000 hours), and will run for a period of approximately 2 hours. Please remove your wristwatch and put it in your pocket. Use only the clocks supplied in the experiment.

I would like to emphasize that we are not giving you a test to see how good an operator you are. This experiment is for the purpose of determining which display is best for extracting target information. The Army is not interested in how good you are as an operator. However, you and your superiors are interested in how good you are. I am sure they will not base the next promotion on how well you do on 6 hours of Army practical exercises. Still, these activations are actual activations recorded in the field and your accuracy in interpreting is one indication or example of what you can do. You will be able to compare what you do to what others do as a group. You will be able to get your score and the group average from your commanding officer. He will be able to assess you objectively against the others on this one sample of one of your duties. However, there are no standards of performance--even if you do worse than everyone else, you still could be a competent operator.

APPENDIX B

TRAINING OF SUBJECTS IN THE USE OF MAP DISPLAYS

A scenario was prepared similar to the three scenarios that the examinees were to see in evaluating the three readout displays. This scenario was in two sections: a training section and a practical exercise (PE) section. The training section consisted of four 30-minute parts, each containing personnel and tracked vehicles. The PE followed the same format with different test items and followed the training after a break.

After the briefing given in Appendix A, the following procedure was presented to the subjects and repeated if necessary during the training and practical exercise sessions:

Procedure for Map Display

1. Watch for blinking lights.

2. If you believe a sensor might have been activated by a target, flag it with a paper clip or grease pencil.

3. Continue to view all lights.

4. When the second sensor in the string is activated, note time on answer sheet if you believe a target might be present.

5. Continue viewing with special attention to activated string.

6. If you decide a target is present, fill out form. If you decide no target is present, write "omit" to right of where you put time in first column.

[Add for map display plus time compression]

7. If you wish to review, tell the monitor the amount of time you wish to review (i.e., 2, 4, 6, 8 minutes). Monitor will stop the clock, reverse the tape the amount of time requested and will play back the tape at 8x normal time to the spot in the tape where you requested the review. He will then start the clock and tape at normal time and you will continue as before. This is a simulation of what would happen in the field. Other equipment would be designed to handle this function if we find it to be helpful.

8. Note that you will have no clock during the review period. If you wish to record time during this period, that is, report a possible target, say loudly to the operator "time." He will tell you the tape

recorder counter numbers which you will use as time in the first or third column on your answer sheet. We will later convert these numbers to the real time. Finally, you also may tell the operator to stop if you wish to fill in the answer sheet and then continue to view at 8x normal time.

To conserve training time, the group monitored the display together. The senior member of each team was chosen as the team leader; one person had the responsibility of computing ground speed, the other completed the answer sheet. In this way, gathered around one readout device, there was interaction among the examinees and answers given to questions by one benefited all.

A participant could ask for a replay of the magnetic tape in compressed time for any portion(s) of the scenario that person wanted to view again. After completion of each half hour section of the training tape, that section was rerun in its entirety in compressed time to insure training in the use of compressed time. After the 2-hour training tape was completed, a discussion followed to allow the experimenters to emphasize the important points to remember and also to give additional time for questions and answers.

Following a break, the examinees took the exercise. The team members took turns in interpreting the display, estimating speed, and completing the report form. The proctors gave assistance in procedure but did not assist in the interpretation.

All of the examinees except two had had experience in interpreting event recorders in field exercises. Additional training on the RO 376 by an experienced UGS operator was given to the two men before the experiment started.

APPENDIX C

TARGET REPORT FORM

_______________________________   _______________________________

Printed NAME & RANK   Date - Time

Display: RO 376 Map Map & 8x Hrs Exp on UGS Displays __________

Score

Time 1st Act. of 2nd Sensor	Pen Nos./ Sensor Nos.	Time ID. as a Tgt.	Velocity	Tgt. Type	No.	Conf.	Remarks

DISTRIBUTION

ARI Distribution List

4 OASD (M&RA)
2 HQDA (DAMI-CSZ)
1 HQDA (DAPE-PBR
1 HQDA (DAMA-AR)
1 HQDA (DAPE-HRE-PO)
1 HQDA (SGRD-ID)
1 HQDA (DAMI-DOT-C)
1 HQDA (DAPC-PMZ-A)
1 HQDA (DACH-PPZ-A)
1 HQDA (DAPE-HRE)
1 HQDA (DAPE-MPO-C)
1 HQDA (DAPE-DW)
1 HQDA (DAPE-HRL)
1 HQDA (DAPE-CPS)
1 HQDA (DAFD-MFA)
1 HQDA (DARD-ARS-P)
1 HQDA (DAPC-PAS-A)
1 HQDA (DUSA-OR)
1 HQDA (DAMO-RQR)
1 HQDA (DASG)
1 HQDA (DA10-PI)
1 Chief, Consult Div (DA-OTSG), Adelphi, MD
1 Mil Asst. Hum Res, ODDR&E, OAD (E&LS)
1 HQ USARAL, APO Seattle, ATTN: ARAGP-R
1 HQ First Army, ATTN: AFKA-OI-TI
2 HQ Fifth Army, Ft Sam Houston
1 Dir, Army Stf Studies Ofc, ATTN: OAVCSA (DSP)
1 Ofc Chief of Stf, Studies Ofc
1 DCSPER, ATTN: CPS/OCP
1 The Army Lib, Pentagon, ATTN: RSB Chief
1 The Army Lib, Pentagon, ATTN: ANRAL
1 Ofc, Asst Sect of the Army (R&D)
1 Tech Support Ofc, OJCS
1 USASA, Arlington, ATTN: IARD-T
1 USA Rsch Ofc, Durham, ATTN: Life Sciences Dir
2 USARIEM, Natick, ATTN: SGRD-UE-CA
1 USATTC, Ft Clayton, ATTN: STETC-MO-A
1 USAIMA, Ft Bragg, ATTN: ATSU-CTD-OM
1 USAIMA, Ft Bragg, ATTN: Marquat Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Tng Dir
1 USA Quartermaster Sch, Ft Lee, ATTN: ATSM-TE
1 Intelligence Material Dev Ofc, EWL, Ft Holabird
1 USA SE Signal Sch, Ft Gordon, ATTN: ATSO-EA
1 USA Chaplain Ctr & Sch, Ft Hamilton, ATTN: ATSC-TE-RD
1 USATSCH, Ft Eustis, ATTN: Educ Advisor
1 USA War College, Carlisle Barracks, ATTN: Lib
2 WRAIR, Neuropsychiatry Div
1 DLI, SDA, Monterey
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-WGC
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-MR
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-JF
1 USA Artic Test Ctr, APO Seattle, ATTN: STEAC-MO-ASL
1 USA Artic Test Ctr, APO Seattle, ATTN: AMSTE-PL-TS
1 USA Armament Cmd, Redstone Arsenal, ATTN: ATSK-TEM
1 USA Armament Cmd, Rock Island, ATTN: AMSAR-TDC
1 FAA-NAFEC, Atlantic City, ATTN: Library
1 FAA-NAFEC, Atlantic City, ATTN: Hum Engr Br
1 FAA Aeronautical Ctr, Oklahoma City, ATTN: AAC-44D
2 USA Fld Arty Sch, Ft Sill, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DI-E
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DT-TP
1 USA Armor Sch, Ft Knox, ATTN: ATSB-CD-AD
2 HQUSACDEC, Ft Ord, ATTN: Library
1 HQUSACDEC, Ft Ord, ATTN: ATEC–EX–E–Hum Factors
2 USAEEC, Ft Benjamin Harrison, ATTN: Library
1 USAPACDC, Ft Benjamin Harrison, ATTN: ATCP–HR
1 USA Comm–Elect Sch, Ft Monmouth, ATTN: ATSN–EA
1 USAEC, Ft Monmouth, ATTN: AMSEL–CT–HDP
1 USAEC, Ft Monmouth, ATTN: AMSEL–PA–P
1 USAEC, Ft Monmouth, ATTN: AMSEL–SI–CB
1 USAEC, Ft Monmouth, ATTN: C, Facl Dev Br
1 USA Materials Sys Anal Agcy, Aberdeen, ATTN: AMXSY–P
1 Edgewood Arsenal, Aberdeen, ATTN: SAREA–BL–H
1 USA Ord Ctr & Sch, Aberdeen, ATTN: ATSL–TEM–C
2 USA Hum Engr Lab, Aberdeen, ATTN: Library/Dir
1 USA Combat Arms Tng Bd, Ft Benning, ATTN: Ad Supervisor
1 USA Infantry Hum Rsch Unit, Ft Benning, ATTN: Chief
1 USA Infantry Bd, Ft Benning, ATTN: STEBC–TE–T
1 USASMA, Ft Bliss, ATTN: ATSS–LRC
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA–CTD–ME
1 USA Air Def Sch, Ft Bliss, ATTN: Tech Lib
1 USA Air Def Bd, Ft Bliss, ATTN: FILES
1 USA Air Def Bd, Ft Bliss, ATTN: STEBD–PO
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Lib
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: ATSW–SE–L
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Ed Advisor
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: DepCdr
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: CCS
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO–E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC–CI
1 USAECOM, Night Vision Lab, Ft Belvoir, ATTN: AMSEL–NV–SD
3 USA Computer Sys Cmd, Ft Belvoir, ATTN: Tech Library
1 USAMERDC, Ft Belvoir, ATTN: STSFB–DQ
1 USA Eng Sch, Ft Belvoir, ATTN: Library
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL–TD–S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL–GSL
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: CTD–MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS–CTD–MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TEX–GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTS–OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTD–DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTD–CS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: DAS/SRD
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TEM
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
1 CDR, HQ Ft Huachuca, ATTN: Tech Ref Div
2 CDR, USA Electronic Prvg Grd, ATTN: STEEP–MT–S
1 CDR, Project MASSTER, ATTN: Tech Info Center
1 Hq MASSTER, USATRADOC, LNO
1 Research Institute, HQ MASSTER, Ft Hood
1 USA Recruiting Cmd, Ft Sherdian, ATTN: USARCPM–P
1 Senior Army Adv., USAFAGOD/TAC, Elgin AF Aux Fld No. 9
1 HQ USARPAC, DCSPER, APO SF 96558, ATTN: GPPE–SE
1 Stimson Lib, Academy of Health Sciences, Ft Sam Houston
1 Marine Corps Inst., ATTN: Dean–MCI
1 HQUSMC, Commandant, ATTN: Code MTMT 51
1 HQUSMC, Commandant, ATTN: Code MPI–20
2 USCG Academy, New London, ATTN: Admission
2 USCG Academy, New London, ATTN: Library
1 USCG Training Ctr, NY, ATTN: CO
1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
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